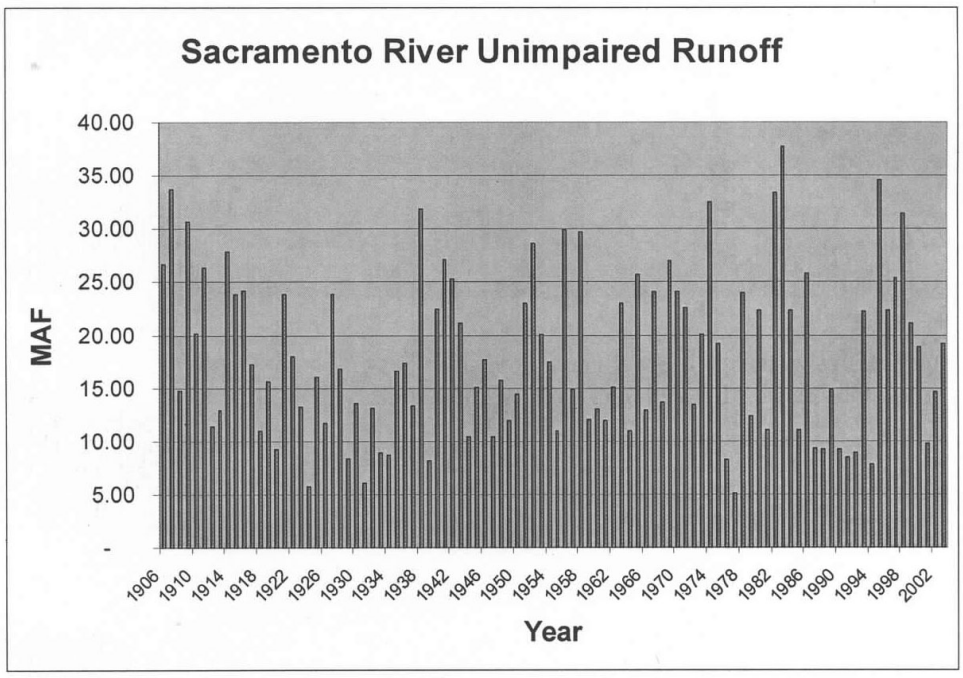
Hydrology

California River Indices

Hydrology: California's water development has generally been dictated by extremes of droughts and floods. The six-year drought of 1929-34 established the criteria commonly used to plan storage capacity or water yield of large Northern California reservoirs. The influence of climatic variability on California's water supplies is much less predictable than the influences of geographic and seasonal variability, as evidenced by the recent historical records of precipitation and runoff. For example, the State's average annual runoff includes the all-time low of 15 maf in 1977 and the all-time high of over 135 maf in 1983. Floods and droughts occur often, sometimes in the same year. The January 1997 flood was followed by a record-setting dry period from February through June, and the flooding of 1986 was followed by six years of drought (1987-92).

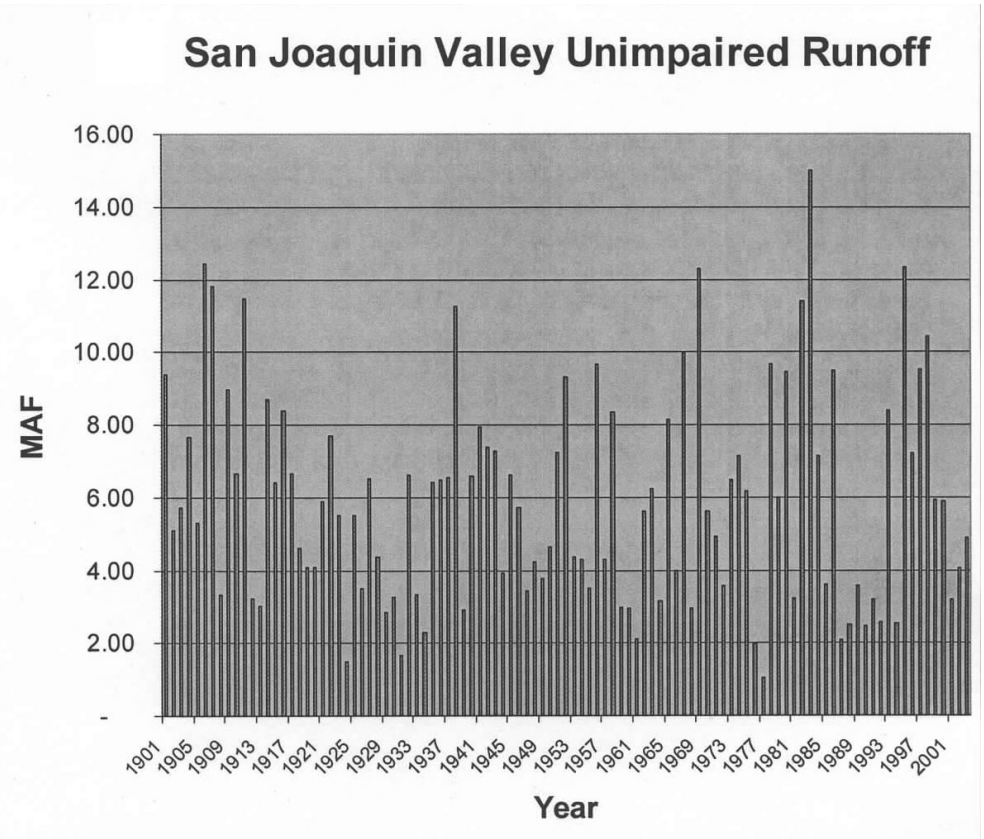
Figures showing the estimated annual unimpaired runoff of the Sacramento and San Joaquin River basins illustrate climatic variability. Because these basins provide much of the State's water supply, their hydrology is often used as indices of water year classification systems.

Unimpaired runoff represents the natural water production of a river basin, unaltered by upstream diversions, storage, and export of water to or import of water from other basins.



Unimpaired runoff represents the natural water production of a river basin, unaltered by upstream diversions, storage, export of water to or import of water from other basins.

Sacramento River Runoff is the sum (in maf) of Sacramento River at Bend Bridge, Feather River inflow to Lake Oroville, Yuba River at Smartville, and American River inflow to Folsom Lake. The water year sum is also known as the Sacramento River Index, and was previously referred to as the "4 River Index" or "4 Basin Index". It was previously used to determine year type classifications under SWRCB Decision 1485.



San Joaquin River Runoff is the sum of Stanislaus River inflow to New Melones Lake, Tuolumne River inflow to New Don Pedro Reservoir, Merced River inflow to Lake McClure, and San Joaquin River inflow to Millerton Lake (all in maf).

Water Year Classification: Water year classification systems provide a means to assess the amount of water originating in a basin. Because water year classification systems are useful in water planning and management, they have been developed for several hydrologic basins in California. The Sacramento Valley 40-30-30 Index and the San Joaquin Valley 60-20-20 Index were developed by the State Water Resources Control Board (SWRCB) for the Sacramento and San Joaquin River hydrologic basins as part of SWRCB's Bay-Delta regulatory activities. Both systems define one "wet" year classification, two "normal" classifications (above and below normal), and two "dry" classifications (dry and critical), for a total of five water year types.

Sacramento Valley Water Year Index = (0.4) x Current Apr-Jul runoff forecast (in maf) + (0.3) x Current Oct-Mar runoff (in maf) + (0.3) x Previous Water Year's Index (if the Previous Water Year's Index exceeds 10.0, then 10.0 is used).

This index, originally specified in the 1995 SWRCB Water Quality Control Plan, is used to determine the Sacramento Valley water year type as implemented in SWRCB D-1641. Year types are set by first of month forecasts beginning in February. Final determination is based on the May 1 50 percent exceedence forecast.

Sacramento Valley Water Year Hydrologic Classifications are:

Year Type	Water Year Index
Wet	Equal to or greater than 9.2
Above Normal	Greater than 7.8, and less than 9.2
Below Normal	Greater than 6.5, and equal to or less than 7.8
Dry	Greater than 5.4, and equal to or less than 6.5
Critical	Equal to or less than 5.4

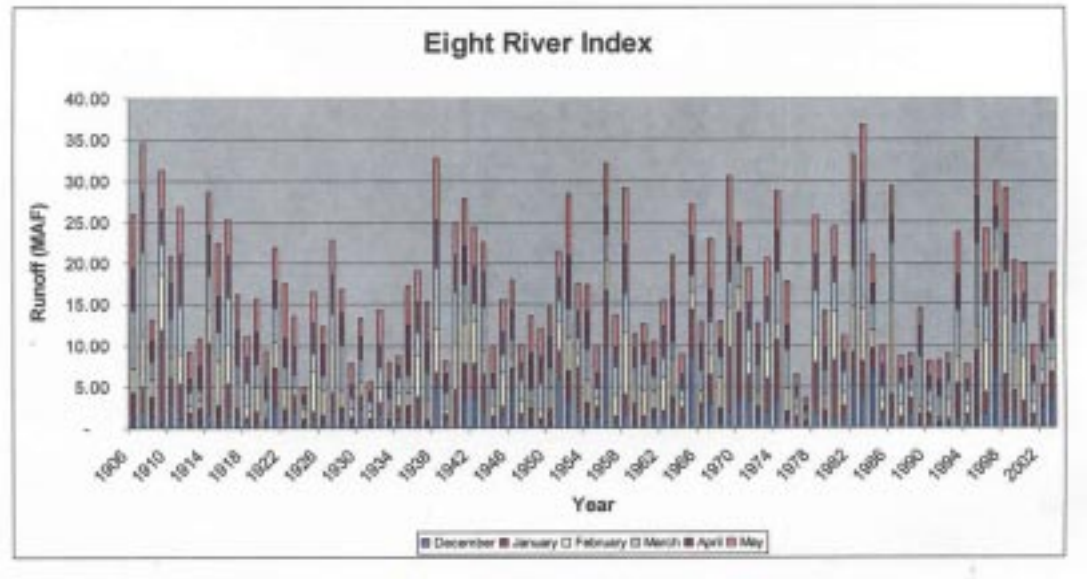
San Joaquin Valley Water Year Index = (0.6) x Current Apr-Jul runoff forecast (in maf) + (0.2) x Current Oct-Mar runoff (in maf) + (0.2) x Previous Water Year's Index (if the Previous Water Year's Index exceeds 4.5, the 4.5 is used).

This index, originally specified in the 1995 SWRCB Water Quality Control Plan, is used to determine the San Joaquin Valley water year type as implemented in SWRCB D-1641. Year types area set by first of month forecasts beginning in February. Final determination for San Joaquin River flow objectives is based on the May 1 75 percent exceedence forecast.

San Joaquin Valley Water Year Hydrologic Classifications are:

Year Type	Water Year Index
Wet	Equal to or greater than 3.8
Above Normal	Greater than 3.1, and less than 3.8
Below Normal	Greater than 2.5, and equal to or less than 3.1
Dry	Greater than 2.1, and equal to or less than 2.5
Critical	Equal to or less than 2.1

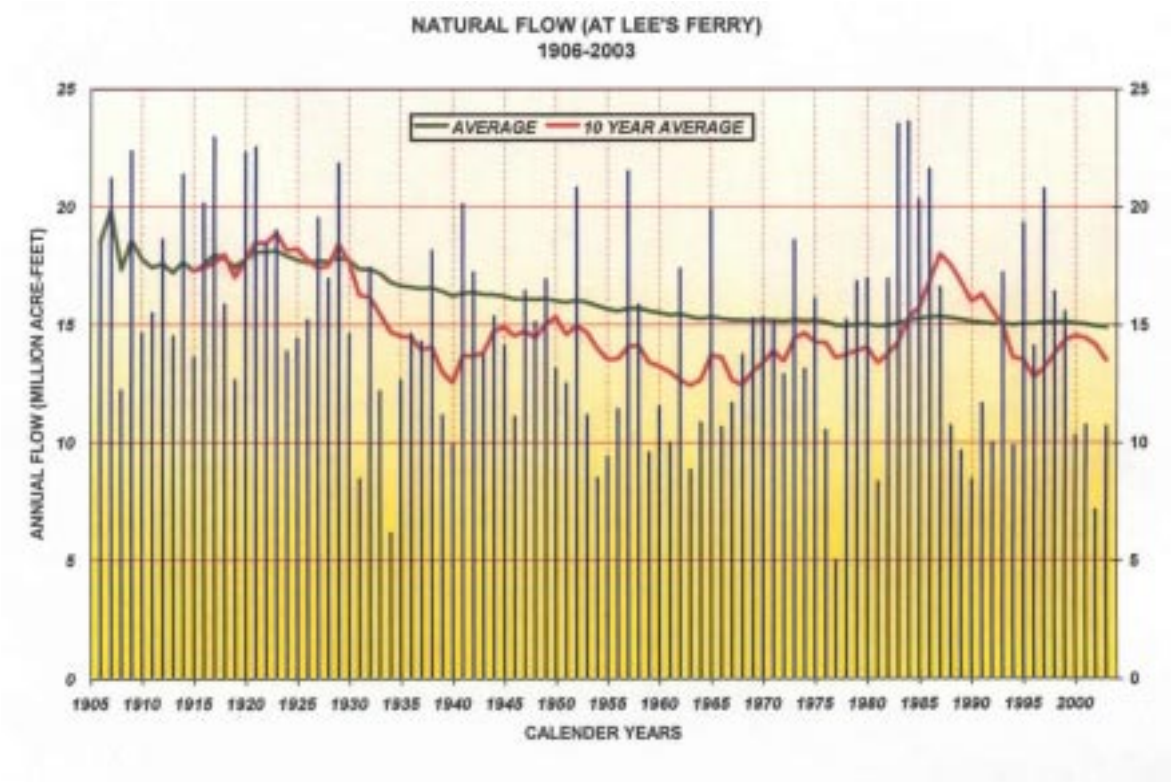
Eight River Index = Sacramento River Runoff + San Joaquin River Runoff.
This Index is used from December through May to set flow objectives as implementer in SWRCB Decision 1641.



Colorado River

The Colorado River is an interstate and international river. Its mean annual unimpaired flow is about 15 maf. The river, which has its headwaters in Wyoming's Green River Basin, crosses through parts of seven states before flowing into Mexico and terminating at the Gulf of California.

Defining a representative drought in Southern California is complicated by the region's access to imported supplies from the Colorado River. Three major facilities—USBR's All American Canal, MWDSC's Colorado River Aqueduct, and Palo Verde Irrigation District's main canal—convey water from the Colorado River to California users. The Colorado River watershed is large (about 244,000 square miles, or roughly 10 times the size of the Sacramento River watershed) and experiences hydrologic conditions different than California's. As a result, Southern California's water supply may be buffered from the effects of severe drought in Northern California. The following figure presents Colorado River unimpaired flow at the Lee Ferry interstate compact measurement point to illustrate the river basin's hydrology.



Frequency of a 100-Year Flood

By Definition

Probability of a 100-Year Flood occurring in a given year = 1/100

Therefore

Probability of a 100-Year Flood Not occurring in a given year = (1 – 1/100)

Probability of a 100-Year Flood Not occurring in 30 years = (1 - 1/100) ^ 30 = 0.7397

Therefore

Probability of a 100-Year Flood occurring at least once in the next 30 Years = 1 – 0.7397 = 26%

Many Californians have a false sense of safety from floods, the result of incomplete information. Current flood threats are higher than commonly thought; the term "100-year flood," for example, is misleading. It does not denote a flood that will occur only once every 100 years, as is commonly believed. Rather, it is the flood elevation (or flow) that has a one-percent chance of being equaled or exceeded each year. "Over the lifetime of a 30-year mortgage, there is a 26-percent chance of being flooded by a 100-year flood."

Major Floods Since 1950

Wet water years are not necessarily indicative of flood conditions. Although water year 1983 was the wettest in California this century, major flooding did not occur. The following table shows estimated unimpaired runoff from a few of the State's larger floods since the 1950s. In January 1997, California confronted one of the largest and most extensive flood disasters in its history. Rivers across the State from the Oregon border to the southern Sierra reached flood stages. Flood volumes of some rivers exceeded channel capacities by as much as 700 percent. In many major river systems, flood control dams reduced peak flows by one-half or more. Even so, leveed flood control systems were overwhelmed in some areas. Flood damage costs are nearing $2 billion.

Unimpaired Runoff				
River	**Location**	**Date**	**Max 1-Day (cfs)**	**3-day Volume (taf)**
Sacramento	Shasta Dam	Jan 1974	196,000	779
		Feb 1986	126,000	681
		Jan 1997	216,000	1,000
Feather	Oroville Dam	Dec 1964	179,000	984
		Feb 1986	217,000	1,113
		Jan 1997	298,000	1,392
Yuba	Marysville	Dec 1964	144,000	703
		Feb 1986	142,000	729
		Jan 1997	161,000	736
American	Folsom Dam	Dec 1964	183,000	835
		Feb 1986	171,000	988
		Jan 1997	249,000	977
Mokelumne	Camanche Dam	Dec 1964	36,000	171
		Feb 1986	28,000	149
		Jan 1997	76,000	233
Stanislaus	New Melones Dam	Dec 1964	44,000	198
		Feb 1986	40,000	246
		Jan 1997	73,000	298
Tuolumne	New Don Pedro Dam	Dec 1964	73,000	306
		Feb 1986	53,000	294
		Jan 1997	120,000	548

Merced	New Exchequer Dam	Dec 1964	33,000	136
		Feb 1986	30,000	164
		Jan 1997	67,000	262
San Joaquin	Friant Dam	Feb 1986	33,000	176
		Mar 1995	39,000	156
		Jan 1997	77,000	313
Truckee	Reno	Oct 1963	25,000	79
		Feb 1986	22,000	112
		Jan 1997	37,000	148
Cosumnes	Michigan Bar	Dec 1964	29,000	115
		Feb 1986	34,000	196
		Jan 1997	60,000	N/A
Eel	Scotia	Dec 1964	648,000	2,936
		Feb 1986	304,000	1,515
Santa Ynez	Lompoc[a]	Jan 1969	38,000	175
Salinas	Spreckles[a]	Feb 1969	65,000	252
		Mar 1983	60,000	314
		Mar 1995	64,000	241
Santa Clara	Saticoy	Feb 1969	92,000	270

[a] Impaired flows

Severity of Extreme Droughts in Sacramento and San Joaquin Valley

Numerous multi-year droughts have occurred in California this century: 1912-13, 1918-20, 1922-24, 1929-34, 1947-50, 1959-61, 1976-77, and 1987-92. In order to provide water supply reliability, major reservoirs are designed to maintain and deliver carryover storage through several years of drought. The 1929-34 drought established the criteria commonly used to design the storage capacity and water yield of large Northern California reservoirs. Many reservoirs built since this drought were sized to maintain a reliable level of deliveries should a repeat of the 1929-34 hydrology occur. Even a single critical runoff year such as 1977 can be devastating to water users with limited storage reserves, who are more dependent on annual runoff. Following table compares the severity of recent droughts with the 1929-34 drought in the Sacramento Valley and San Joaquin Valley.

Drought Period	Sacramento Valley Runoff		San Joaquin Valley Runoff	
	(maf/yr)	(% Average 1901-96)	(maf/yr)	(% Average 1906-96)
1929-34	9.8	55	3.3	57
1976-77	6.6	37	1.5	26
1987-92	10.0	56	2.8	47

Groundwater supplies about 30 percent of California's urban and agricultural applied water use. In drought years when surface water supplies are reduced, groundwater supports an even greater percentage of use, resulting in declining groundwater levels in many areas. For example, during the first five years of the 1987-92 drought, groundwater extractions exceeded groundwater recharge by 11 maf in the San Joaquin Valley. Drawing down groundwater reserves in drought years is analogous to reservoir carryover storage operations.